Safety Data Sheet

Glyoxal

Division of Safety
National Institutes
of Health

WARNING!

THIS COMPOUND IS MODERATELY TOXIC AND MUTAGENIC. IT IS READILY ABSORBED THROUGH THE INTESTINAL TRACT. IT MAY CAUSE SEVERE IRRITATION OF TISSUES (SKIN, EYES, MUCOUS MEMBRANES, AND LUNGS) AND INDUCE SENSITIVITY. AVOID FORMATION AND BREATHING OF AEROSOLS OR VAPORS.

LABORATORY OPERATIONS SHOULD BE CONDUCTED IN A FUME HOOD, GLOVE BOX, OR VENTILATED CABINET.

AVOID SKIN CONTACT: IF EXPOSED, WASH WITH SOAP AND COLD WATER. AVOID RUBBING OF SKIN OR INCREASING ITS TEMPERATURE.

GLYOXAL, IN THE PRESENCE OF LIMITED AMOUNTS OF WATER AND AIR, IS FLAMMABLE AND EXPLOSIVE. KEEP AWAY FROM SPARKS AND OPEN FLAMES. IN CASE OF FIRE, USE CARBON DIOXIDE OR DRY CHEMICAL EXTINGUISHER.

FOR EYE EXPOSURE, IRRIGATE IMMEDIATELY WITH LARGE AMOUNTS OF WATER. FOR INGESTION, DRINK MILK OR WATER. REFER FOR GASTRIC LAVAGE. FOR INHALATION, REMOVE VICTIM PROMPTLY TO CLEAN AIR. ADMINISTER RESCUE BREATHING IF NECESSARY. REFER TO PHYSICIAN.

IN CASE OF LABORATORY SPILL, WEAR PROTECTIVE CLOTHING DURING CLEANUP. AVOID SKIN CONTACT OR BREATHING OF AEROSOLS OR VAPORS. USE AN EXCESS OF WATER TO DISSOLVE COMPOUND. USE ABSORBENT PAPER TO MOP UP SPILL. WASH DOWN AREA WITH SOAP AND WATER. DISPOSE OF WASTE SOLUTIONS AND MATERIALS APPROPRIATELY.

A. Background

Glyoxal is a yellow crystalline compound at temperatures below its melting point (15°C). It is soluble in anhydrous solvents and in

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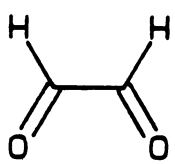
excess of water, but polymerizes in the presence of traces of water and in solvents containing water. Its toxicity (oral, parenteral) is relatively low but it is moderately irritating to skin, eyes, and mucous membranes. Glyoxal is virucidal and moderately mutagenic but no carcinogenic effects have been reported. Its main industrial uses are due to its reactivity with starch, cellulose, and other carbohydrates and with proteins and include paper manufacture, improvement of resistance of textiles to shrinkage and creasing, leather tanning, and manufacture of photographic materials (Brown et al., 1980). The use of glyoxal in chemical synthesis of heterocycles and its industrial uses have been reviewed (Mattioda et al., 1983).

Chemical and Physical Data

1. Chemical Abstract No.: 107-22-2.

2. Synonyms: biformyl; diformyl; ethanedial; 1,2-ethanedione; glyoxyl aldehyde; oxalaldehyde.

3. Chemical structure and molecular weight:



$C_2H_2O_2$; 58.04

other forms of this molecule are discussed by Whipple (1970).

4. Density: $d_4^{20} = 1.14$.

5. Absorption spectroscopy: Glyoxal has an absorption maximum at about 355 nm (Arigad, 1983). Absorption spectra in various solvents are sometimes influenced by the choice of solvents (Carpenter and Forster, 1958). The proton magnetic resonance spectrum has been published (Whipple, 1970).

6. Volatility: No data.

7. Solubility: Glyoxal yields stable solutions in anhydrous solvents such as ether, heptane, chloroform, and dioxane. With other solvents (e.g., n-butanol, n-octanol, anisole, pyridine, acetonitrile) a reaction occurs to yield a white solid, probably a polymer (Carpenter and Forster, 1958). The commercial 40% aqueous solution usually contains polymerization inhibitors.

8. Description: Yellow prisms or irregular pieces which turn white on cooling; light yellow liquid above its melting point. The vapors are green and burn with a purple flame (Windholz, 1983).

9. Boiling point: 50.4°C; melting point: 15°C.

10. Stability: Pure glyoxal is stable on storage in absence of oxygen and moisture at -78°C (Carpenter and Forster, 1958). The commercial aqueous solution (in the absence of any statements to the contrary) appears to be stable when polymerization inhibitors are included, as a solid, non-hygroscopic dihydrate [$(C_2H_2O_2)_3 \cdot 2H_2O$] (Windholz, 1983), as are solutions in anhydrous solvents. For a discussion of polymerization and depolymerization reactions see Mattioda et al., 1983. Contact with moisture results in polymerization which may be explosive. Irradiation using a mercury lamp results in photolysis, mainly to carbon monoxide and hydrogen with some formaldehyde (Calvert and Layne, 1953).

11. Chemical reactivity: Glyoxal exhibits all chemical properties of an aliphatic dialdehyde. It is a strong reducing agent (e.g., ammoniacal silver nitrate) and forms mono- and dioximes, hydrazones, and a stable addition compound with sodium bisulfite. In the presence of alkali it undergoes an "internal Cannizzaro reaction" to yield glycolic acid. It is decomposed by chlorosulfonic acid, ethyleneimine, nitric acid, oleum, and sodium hydroxyde (Sax, 1984). Of biological interest is its reaction with guanine and its derivatives and with isocytosine (Staehelin, 1959; Shapiro and Hachmann, 1966).

12. Flash point: No data.

13. Autoignition temperature: No data.

14. Explosive limits in air: No data (but see 10, above).

Fire, Explosion, and Reactivity Hazard Data

1. Fire-fighting personnel should wear protective clothing and air-supplied respirators with full face masks.

2. Pure glyoxal is a potential fire hazard; it reacts violently with limited amounts of water and air, particularly under conditions of fire. Carbon dioxide or dry fire extinguishers should be used. Commercial water solutions are considered to be relatively safe.

3. Alkali, in addition to the above, decomposes glyoxal.

4. Hazardous decomposition products, on exposure to ultraviolet light, include carbon monoxide, formaldehyde, and hydrogen. It is not known if any or all of these products are formed under conditions of fire but precautions for fire-fighting personnel should include this possibility.

Operational Procedures

It should be emphasized that this data sheet and the NIH Guidelines are intended as starting points for the implementation of good laboratory practices when using this compound. The practices and procedures described in the following sections pertain to the National Institutes of Health and may not be universally applicable to other institutions. Administrators and/or researchers at other institutions should modify the following items as needed to reflect their individual management system and current occupational and environmental regulations.

1. Chemical inactivation: No validated method reported.

2. Decontamination: Turn off equipment that could be affected by glyoxal or the materials used for cleanup. If there is any uncertainty regarding the procedures to be followed for decontamination, call the NIH Fire Department (dial 116) for assistance. Use absorbent paper to mop up spill. Wipe off surfaces with alkaline permanganate, then wash with copious quantities of water. Glassware should be rinsed (in a hood) with dilute sodium hydroxide, followed by soap and water. Animal cages should be washed with water.

3. Disposal: No waste streams containing glyoxal shall be disposed of in sinks or general refuse. Surplus glyoxal or chemical waste streams contaminated with glyoxal shall be handled as hazardous chemical waste and disposed of in accordance with the NIH chemical waste disposal system. Nonchemical waste (e.g., animal carcasses and bedding) containing glyoxal shall be handled and packaged for incineration in accordance with the NIH medical-pathological waste disposal system. Potentially infectious waste (e.g., tissue cultures) containing glyoxal shall be packaged for incineration, as above. Burnable waste (e.g., absorbent bench top liners) minimally contaminated with glyoxal shall be handled as potentially infectious waste and packaged for incineration, as above. Absorbent materials (e.g., associated with spill cleanup) grossly contaminated shall be handled in accordance with the chemical waste disposal system. Radioactive waste containing glyoxal shall be handled in accordance with the NIH radioactive waste disposal system.

4. Storage: Store solid glyoxal at freezer temperature in absence of air and moisture. Avoid exposure to light. Store working quantities of glyoxal solutions in an explosion-safe refrigerator in the work area.

Monitoring and Measurement Procedures Including Direct Field Measurements and Sampling for Subsequent Laboratory Analysis

1. Sampling: No data.

2. Analysis: None of the methods described in the literature is specific for glyoxal, but rather for the aldehyde group in

general and, in some cases, for α-dicarbonyl compounds. Volumetric analysis, based either on the Cannizzaro reaction in known excess of alkali and back titration or on bisulfite addition and iodometry, are macro methods and will not be considered further (Salomaa, 1956). Colorimetric procedures specific for α-dicarbonyl and α-hydroxyketones have a useful range of 5-200 nanomoles and are applicable to biological materials (Dechary et al., 1954; Sawicki et al., 1962). Another spectrophotometric method, also applicable to formaldehyde, acetaldehyde, and other aldehydes, has even greater sensitivity (0.5-50 nanomoles) (Avigad, 1983). A gas chromatographic procedure, seen only in abstract form, mentions "microamounts" but sensitivity is not stated; it may not be any more specific than previously mentioned methods (Kawata et al., 1980).

Biological Effects (Animal and Human)

Note: No studies have been reported dealing with the in vivo effects of glyoxal (distribution, metabolism, etc.). It may be assumed that glyoxal is quickly oxidized to glyoxylic and oxalic acid in the animal body. Methyl- and other substituted glyoxals undergo dismutation (e.g., methyl glyoxal → lactic acid) by enzymatic reaction with two glyoxalases (glutathione dependent), but it is not known if the parent compound undergoes the same biological reaction.

1. Absorption: Glyoxal is absorbed by ingestion and parenteral injection. It is an irritant to the skin, eyes, and mucous membranes but there is no indication if systemic effects are produced via these routes.

2. Distribution: No data.

3. Metabolism and excretion: No animal or human data. In vitro glyoxal is converted by tissue extracts under anaerobic conditions to glycolic acid in the presence of glutathione, and oxidized to glyoxylic acid by soluble liver enzymes (Kun, 1952).

4. Toxic effects: a. Animals. The oral (stomach tube) LD50 of glyoxal is 2.02 and 0.76 g/kg in rats and guinea pigs, respectively (Smyth et al., 1941) and the approximate intraperitoneal LD50 in mice is 200 mg/kg (Doull et al., 1964). The intraperitoneal MLD in rats has been reported to be 100 mg/kg (DeWitt et al., 1953). This places glyoxal in the low to moderate toxicity category. In rats, glyoxal administration leads to a transitory hypoglycemia by direct action on the B cells of the pancreas; histologically degranulation, toxic edema, and necrosis of these cells is noted (Schlaak, 1961). In contrast, rabbits and cats, while exhibiting the same histopathological effects, show first an increase in blood sugar, then return to normal, and after a few days another rise. These species also have extensive kidney degeneration (Doerr et al.,

1948). Instillation of glyoxal into rabbit eyes results in corneal dullness and necrosis (Carpenter and Smyth, 1946). Glyoxal is also mildly irritating to animal skin and may cause skin sensitization on repeated exposure (Brown et al., 1980).
b. Viruses. Glyoxal, as well as substituted glyoxals, is virucidal to parainfluenza-3 and Coxsackie A-21 virus (Renis, 1969) and to tobacco mosaic virus (Staehelin, 1959). With the latter, the inactivation appears to be due to reaction with guanine residues, a reaction which has also been demonstrated in vitro (Shapiro and Hachmann, 1966).

5. Carcinogenic effects: None reported; there is some evidence of carcinostatic activity against Leukemia 1210 in mice (French and Freedlander, 1958).

6. Mutagenic and teratogenic effects: Glyoxal is moderately mutagenic in the Ames test against strains TA100 (Bjeldanes and Chew, 1979) and TA102 (Levin et al., 1982).

Emergency Treatment

1. Skin and eye exposure: For skin exposure, remove contaminated clothing and wash skin with soap and water. Avoid rubbing of skin or increasing its temperature. For eye exposure, irrigate immediately with copious quantities of running water for at least 15 minutes. Obtain ophthalmological evaluation.

2. Ingestion: Drink plenty of water or milk. Induce vomiting. Refer for gastric lavage.

3. Inhalation: Remove victim promptly to clean air. Administer rescue breathing if necessary.

4. Refer to physician. Consider treatment for pulmonary irritation.

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